

TECHNOLOGY GUIDE: NCRSTE_TG008

Corridor Planning with Satellite Remote Sensing Imagery



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TABLE OF CONTENTS

	Page
INTRODUCTION	3
PART I: Land Cover Classification	5
1. Image Processing	6
1.1. Data Acquisition	6
1.2. Georectification	6
1.3. Atmospheric Correction	6
1.4. Segmentation and Classification	6
2. Land Cover Classification	8
PART II: Socioeconomic Data	10
3. Introduction	11
4. Data Description	12
4.1. Population	13
4.2. Unemployment Rate and Change in Employment	16
4.3. Average Wages	20
4.4. Per Capita Income	21
5. Summary	24

INTRODUCTION

Environmental streamlining brings together the timely delivery of transportation projects with the protection and enhancement of the environment. It is generally assumed that greater efficiency in acquiring and analyzing data used in EIS preparation, and better data standards, would reduce EIS preparation time and possibly result in less controversy over the report's findings. Environmental or development planning requires geospatial information about the distribution of landscape features. Maps, and to some extent aerial photographs, are the traditional sources of this information. Remote sensing offers tremendous potential for planning purposes because it not only affords a picture of the current state, but unlike aerial photographs, multispectral data can be used to provide information classes, such as land cover and land use. Continuity in temporal classification of land cover and its extension to land use can play a significant role in preparation of a comprehensive development plan and are invaluable in the planning stage of road development projects. Data from the Landsat satellite program are invaluable sources of information for regional- and some local-scale planning. Landsat data at 30 m resolution is suitable for relatively general natural resource classes, such as softwood and hardwood forests, pasture, cropland, residential and industrial areas, water bodies, etc. The U.S. government has funded the Landsat program continually as part of an on-going mapping program and data are relatively very inexpensive.

A north-south interstate highway has been proposed for western Alabama primarily to spur development in what's locally known as "the Black Belt," which historically has lagged in jobs and income. The idea is that the new highway would help revitalize the area, provide a direct route from western Alabama south to the Port of Alabama at Mobile, and enhance economic opportunities along the Tennessee-Tombigbee Waterway. The \$3 billion cost of that project would be partially offset by leasing the highway's right of way for pipelines, fiber optic cables and other utilities.

The proposed highway would follow U.S. 43 from Mobile north to Muscle Shoals via Tuscaloosa and then possibly enter Tennessee (Figure 1). Federal appropriations were secured to conduct a feasibility study. Originally planned between Muscle Shoals and Tuscaloosa, the freeway will be studied all the way south to Mobile. The total route, approximately 320 miles long, would extend from Mobile roughly along a line following the Tombigbee and Black Warrior Rivers to just west of Tuscaloosa, then northward through Fayette, Marion, Franklin and Colbert counties to Tuscumbia. It would connect to Corridor X/U.S. 78 and Interstate 65. The northern portion of the highway is considered in two segments: from Tuscaloosa to Corridor X (~ 60 mi.) and from Corridor X to Tuscumbia (~ 50 mi.). The boundaries of the corridor to be considered for siting the highway were defined by the Alabama Department of Transportation (Figure 1).

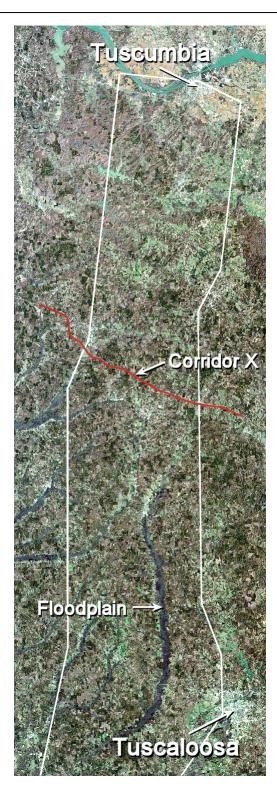


Figure 1. "True-color" image map of the northern half of the proposed Western Alabama Corridor highway. The boundaries of the corridor to restrict siting are shown. Corridor X divides the Western Corridor into two segments.

PART I

Land Cover Classification

NCRSTE_TG008

1. IMAGE PROCESSING

1.1. Acquisition

Four Landsat Thematic Mapper images of the northern two segments of the western Alabama corridor were acquired for the purpose of classifying land cover. Due to the length of the northern portion of the corridor, two images were required to cover the area of interest. To improve classification accuracy, we sought images acquired during the time of year when the leaves are off of the trees and when the vegetation is fully leafed out. A pair of cloud-free images was found in the archives of the U.S. Geological Survey on March 5, 2001 and September 29, 2001.

1.2. Georectification

The images were acquired in TIFF format with Universal Transverse Mercator projection with WGS 1984 horizontal datum. However, as is not uncommon, the georectification of the image pairs from the different dates did not agree. Using an independent source, the images from September were determined to be incorrectly rectified by 57 m in the easterly and 57 m in the northerly directions. An appropriate correction was applied to both September images.

1.3. Atmospheric Correction

The radiance observed by a space-borne sensor is comprised of a component of energy reflected or emitted from Earth's surface as well as from scattering of energy in the atmosphere. The amount of scattering that occurs is a function of wavelength and must be assessed and explicitly removed from each image band. The atmospheric contribution to each image was removed using a modified form of the dark object subtraction technique.

1.4. Segmentation and Classification

In the preliminary classification, the decorrelation stretch images from both March and September 2001 and the tassel cap transformation image from March 2001 were used in the classification. Use of transformation products is sometimes used to reduce the information content of images to a smaller number of bands. In this case, the benefit was minimal so that the final classification was based on the six bands from the March 2001 image and bands 2, 4, and 5 from the September image (Figure 2a).

First the image is segmented. That is, adjacent pixels with similar spectral characteristics are grouped into a segment or image object (Figure 2b). After training by the image analyst, the segments are then clustered into classes (Figure 2c). Thirteen land cover and land use classes were defined for the preliminary classification (Figure 3).

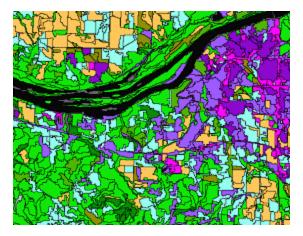
Figure 2a. True color image of a portion of the Western Corridor showing the Tennessee River at Tuscumbia, Alabama.



Figure 2b. Segmented image in which adjacent pixels have been grouped based on similar spectral characteristics. The yellow polygons delineate segments.



Figure 2c. Classified image in which each segment is assigned to a land cover type.



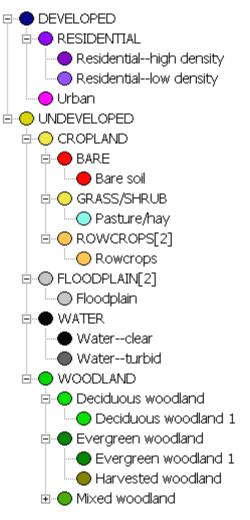


Figure 3. Classification system used in the classification of the Western Alabama Corridor.

2. LAND COVER CLASSIFICATION

True color images of the corridor provide valuable insight into the nature of the terrain and land cover and land use types that the proposed highway might pass through. Floodplains and the number of water bodies that must be crossed or avoided are also readily interpreted from such images. Figure 4 shows the land cover/land use classification results. Most of the area along the northern corridor is in heavily forested land from which timber is harvested. The valleys between areas of relief are commonly occupied by grassland on which cattle are raised. The soil in much of these areas is too rocky for cultivation. Agricultural land dedicated to row crops exists near the northern end in the Tennessee River valley.

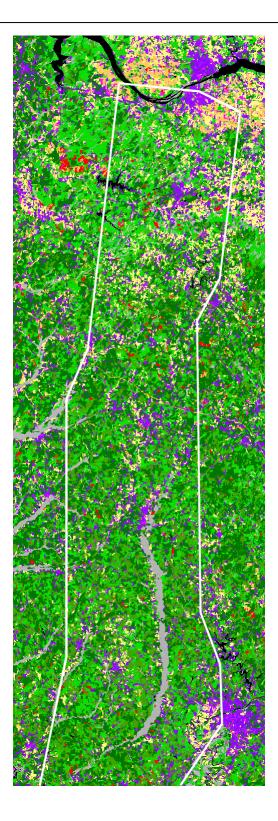


Figure 4. Landcover classification for the northern half of the proposed Western Alabama Corridor.

PART II

Socioeconomic Data

NCRSTE_TG008

3. INTRODUCTION

Engineers of new highway construction projects have to address a number of issues related to socioeconomics and environmental justice to fulfill requirements of NEPA. There are numerous sources of socioeconomic data from state and federal archives that can be accessed via the Internet. Increasingly, these data are available in a commonly used geospatial format adhering to open GIS standards.

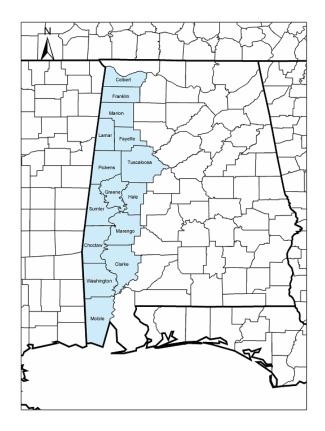
The study area for the western Alabama corridor project consists of 15 counties (Choctaw, Clarke, Colbert, Fayette, Franklin, Greene, Hale, Lamar, Marengo, Marion, Mobile, Pickens, Sumter, Tuscaloosa and Washington) (Figure. 5). We located and acquired the following data sets for the counties in western Alabama and created ARC/Info GIS data layers for each:

- Average wages
- Average wages by job and by percentage of Alabama population
- Inflation adjusted wages
- Population
- Per capita income
- Income relative to state population
- Income relative to national population
- Employment
- Unemployment

The data in all of the above categories are available yearly from 1970 to 2000. In addition to these datasets, changes in 5-year increments are available for all categories. Figure 6 is an example of these data. These socio-economic indicators are closely related. Employment opportunities clearly encourage in migration of new population and the availability of unemployed population can also attract firms to locate in the area. Greater economic activity would be expected to increase per capita incomes and average wage rates, unless all the new employment is unskilled labor.

Much of the study area is considered one of the most disadvantaged areas in the country. The statistics presented below clearly demonstrate the negative trends that have been apparent in the study area. These depressed economic conditions are a major rationale for the transportation corridor. Experience with corridors targeting economic development in many other states has tended to indicate that economic development is fostered at "nodes" along the corridor as opposed to equally distributed development along the length of the new transportation corridor. These nodes tend to be located where the new corridor passes through a major town or city and where it intersects another important existing corridor. If this experience holds true in the case of the proposed western Alabama corridor, it would be expected that economic development would be particularly dramatic in Demopolis that is a major town at the intersection of US highway 80 and Alabama Rt. 43. Also, there would likely be development along the segment that intersects and parallels interstate 20/59 in the Tuscaloosa area. In addition, the intersection of the new corridor with US Highway 78 at Hamilton in Marion County might also experience significant economic development. At each end of the proposed corridor (Mobile and

Tuscumbia) there might also be some effect, although based on the existing size of these areas the effect may not be as perceptible as in the cases listed above.



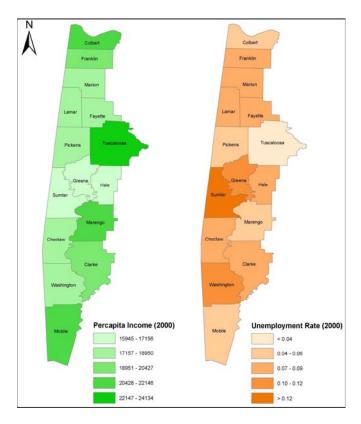


Figure 5. Western corridor counties for which data was acquired.

Figure 6. Year 2000 per capita income (left) and unemployment (right) in the western corridor counties.

4. DATA DESCRIPTION

The western Alabama corridor is a thinly populated area of 15 counties along the western $1/3^{rd}$ of the state (Figure 5). The corridor has a population density of 56 persons/mi², well below the national average of 77. Tuscaloosa and Mobile counties are the most populated counties in the corridor, each with more than 100 persons per square mile. All counties except four in the middle of the corridor have seen modest population growth in past thirty years. Unemployment along the corridor is significantly higher than the national and state averages; however, the 8% level in 2000 is down from 15-16% in mid eighties. Average wages along the corridor were \$25,190 in year 2000 (about 93% of the national average). Per capita income in all the corridor counties, except Tuscaloosa, is below the state average by as much as a third. Figure 6 shows the per capita income and unemployment rate in the 15 counties. It clearly shows that counties with larger cities have higher per capita income as well as lower unemployment rates. The smaller counties suffer from high unemployment rates, probably reflecting lower per capita incomes.

4.1. Population

The U.S. Census was the source of the population data from 1970 to 2000 (Figure 7). In 1970, nine counties (Washington, Choctaw, Sumter, Greene, Hale, Fayette, Lamar, Marengo, and Pickens) had less than 24,000 persons and by 2000 the same counties still had population below 24,000. Also, there were three counties Lamar, Greene and Hale) in 1970 with populations under 16,000 and by 2000 there were four counties (Lamar, Greene, Choctaw and Hale with population below this level. These levels of population were more or less continuous throughout the 1970-2000 period. However some progress was made during the 1970-1985 period where population, particularly in Lamar and Marengo, but the declining trend recurred in1990-2000.

Except for the Muscle Shoals, Tuscaloosa and Mobile areas, much of the region has had very stagnant population growth. Population has actually decreased in Choctaw, Marengo, Sumter and Greene. These latter counties comprise the "Black Belt" portion of the corridor study area. In several other counties, Clarke and Pickens, population increase was 5% or less over the 30 year period (Figure 8). The only county with no growth or loss of growth in the 1970-1975 period was Hale, but the number of counties experiencing no growth increased dramatically between 1970 and 1990. No growth counties grew from one in 1970-1975, to four in 1975-1980, to seven in 1980-1985 and 13 in 1985-1990. The greatest period of decline was 1985-1990. During this period all the counties in the area experienced no growth except for Tuscaloosa and Hale, and the latter only grew by less that 3% (Figure 8). Some minimal reversal of the decline began in the 1990's, however even these gains were generally small.

The data from 1970-2000 clearly indicate that the study area, the counties of the proposed West Alabama corridor in general had a very low level of population and that no growth and loss of population was very common. In terms of population trends, the area the data documents the study area as one of continuous population decline.

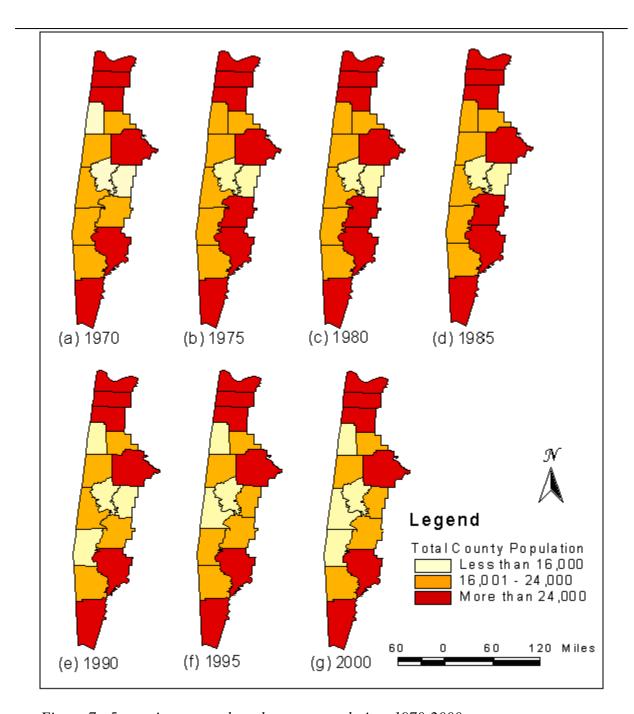


Figure 7: 5-year incremental total county population, 1970-2000.

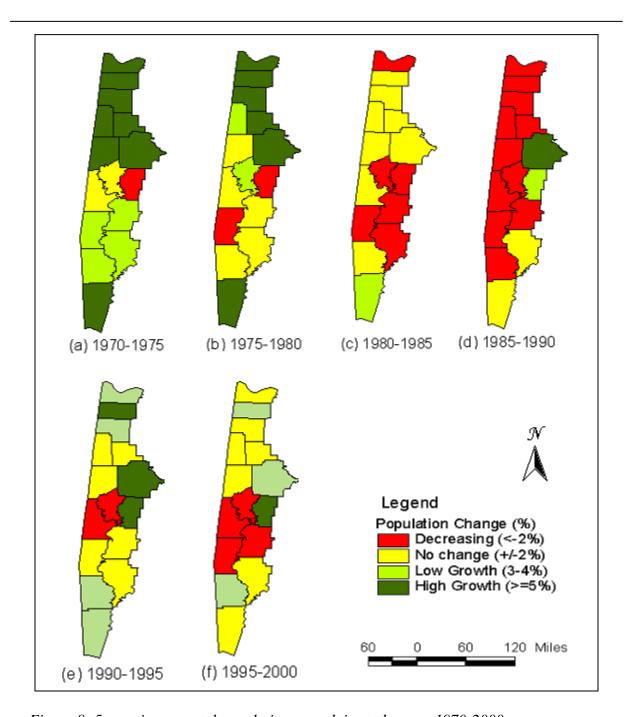


Figure 8: 5-year incremental population growth in study area, 1970-2000.

4.2. Unemployment Rate and Change in Employment

The Bureau of Economic Analysis of the US Department of Commerce is a source of employment and unemployment data. Often the employment rate can be a better indicator of economic activity than unemployment rate, based on the method used in calculating unemployment as only those who are actively seeking employment. Thus, it is quite possible to have a significant element of the population who is unemployed, but do not get counted because they haven't applied for a job in a certain time period. This results in the understatement of unemployment rate.

Employment opportunities in rural areas are very limited in the study area. Forestry is the dominant employment with very little agriculture. The agriculture that does exist is animal production, mostly beef cattle, with very little row crop agriculture. Catfish aquaculture has grown dramatically in Hale and Greene counties. Although catfish production does not offer substantial employment opportunities, harvesting and processing do employ a considerable level of unskilled labor. The major processing hub is Greensboro in Hale County. As with catfish aquaculture the production process does afford much employment opportunity, but harvesting and processing do hire a considerable level of employment. In both cases (aquaculture and forestry), most of the employment is unskilled labor, thus receiving low wages (discussed later).

Unemployment rate has been quite high throughout the 1970-2000 period in the study area (Figure 9). Using 7% as an indicator of high unemployment and 10% as very high, it is apparent that very little of the area has been spared high unemployment. For the purposes of this discussion, 6% unemployment or lower will be considered acceptable. In 1970, the unemployment picture was actually the best of the entire study period. From this point, unemployment increased steadily through 1985. In 1970, there were 8 counties with unemployment 6% or less. There were 5 counties (Clarke, Choctaw, Sumter, and Colbert with high unemployment and two counties (Greene and Franklin) with very high unemployment. By 1975, there were only 3 counties (Mobile, Sumter and Tuscaloosa) with acceptable levels of unemployment and 3 counties (Greene, Hale and Franklin) actually had unemployment exceeding 12%. In 1980, there were no counties with an acceptable level of unemployment and seven counties (Sumter, Greene, Hale, and Pickens, Marion, Franklin and Colbert) with very high unemployment. The low point for unemployment in the study area appears to be in 1985. Not only were there no counties with an acceptable level of unemployment, but also there were 13 counties with very high levels and nine (Washington, Choctaw, Sumter, Greene, Pickens, Fayette Marion, Franklin and Colbert) that exceeded 12%. From 1990 to 2000, only Tuscaloosa and Mobile counties reached an acceptable level throughout the period. Washington and Greene counties exceed 10% for the entire 1990-2000 period.

Increase in employment in the study area during 1970-2000 has not been adequate except with a few exceptions (Figure 10). For the purposes of this discussion, 17% or greater growth in employment will be considered good, 10-16 percept acceptable, below 10% low growth and, of course, 0% and below as no growth or loss in employment. Annual values are determined by dividing the 5-year rates by 5; for example, 10% growth over these time periods is only 2% annual growth, considered a "breakeven" rate. Likewise, annual rates for the entire period (1970-2000) are determined by dividing the period total by 30.

In 1970, there were seven counties (Washington, Clarke, Choctaw, Marengo, Hale, Pickens, and Lamar) with loss in employment or no growth (Figure 10). 1975-1980 was the best period

having only two counties (Greene and Sumter) with loss or no growth and two counties (Fayette and Pickens) with low growth. The rest of the counties had acceptable or high growth in employment. From that point, there was a rather steady decline in employment, reaching a low point in 1995-2000. The entire region experienced low growth. Only three counties (Marengo, Tuscaloosa and Marion) had any growth in employment (Figure 11).

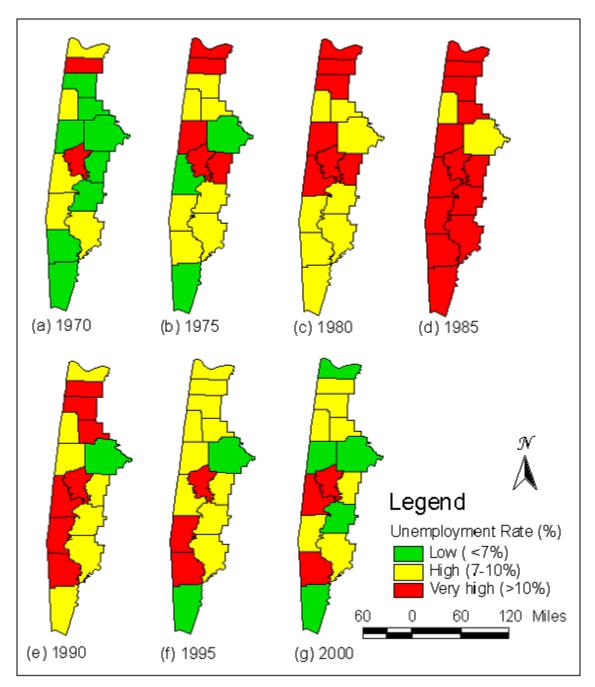


Figure 9: 5-year incremental unemployment rates, 1970-2000.

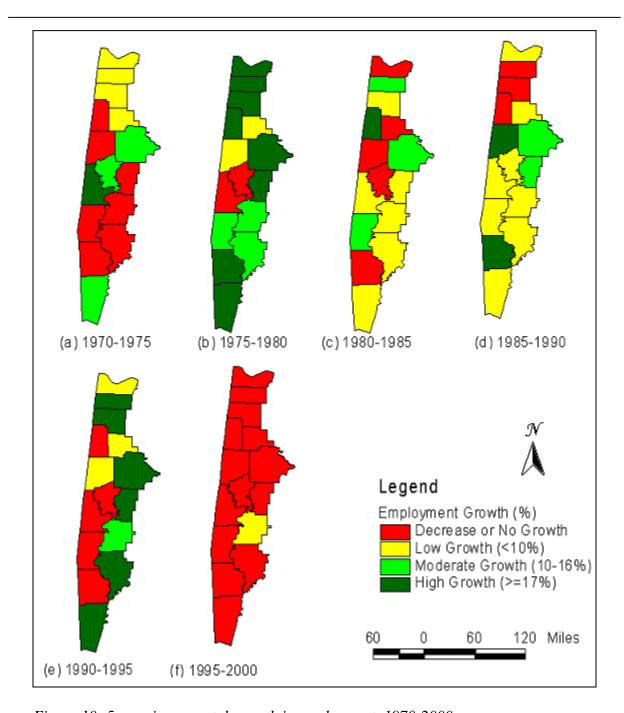


Figure 10: 5-year incremental growth in employment, 1970-2000.

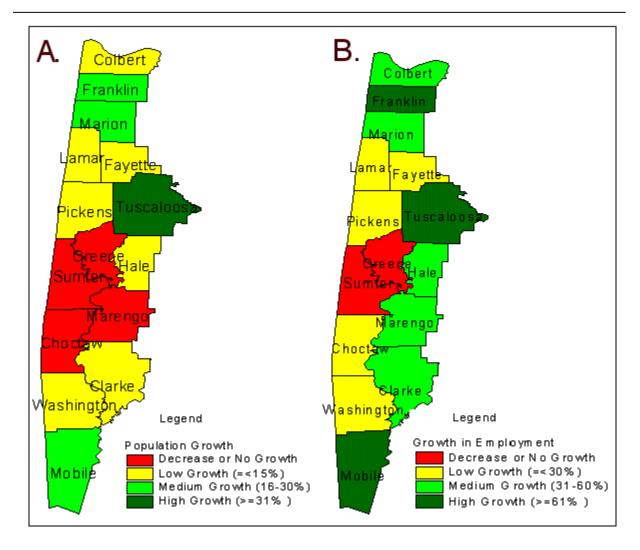


Figure 11: Thirty year trend in population growth (A.) and employment (B.) from 1970-2000.

4.3. Average Wages

Wage data was obtained from the Bureau of economic Analysis of the US Department of Commerce. In 1970, Colbert County (Muscle Shoals) was the only county in the study area in which annual average wages exceeded \$6,000 (Figure 12). Six counties (Marengo, Sumter, Hale, Greene, Pickens and Lamar) had average annual wages less than \$4,000. From this very low level, average wages increased over the study period with inflation. By 2000, there were 8 counties (Hale, Clarke, Sumter, Greene, Pickens, Fayette, Marion and Franklin) with average annual wages below \$24,000.

The average annual wages of each county normalized with respect to the state average (Figure 13). In 1970, only three counties (Mobile, Washington and Colbert) equaled or exceeded the state average. During the same time period, eight counties (Marengo, Sumter, Hale, Greene, Pickens, Lamar, Fayette and Franklin) were less than 80% of the state average. The year with the most counties equaling or exceeding the state average was 1985 in which 5 counties (Colbert, Tuscaloosa, Choctaw, Washington and Mobile. There was a slow steady decline during most of study period. By 2000, there were only two counties (Washington and Choctaw) that reached the state average. Concurrently, six counties (Franklin, Fayette, Pickens, Greene, Hale and Sumter) were below 80% of the state average.

Several observations are necessary to put these wage data into perspective. One, these data is for full time employment, and thus, do not include temporary wages. Second, and more importantly, wages may actually increase when unemployment increase, because generally unemployment in the area is most likely to be unskilled, low wage earners. This observation can be documented by comparing relative wages and unemployment in 1985. This year had the highest relative wages and the worst unemployment during the entire study period.

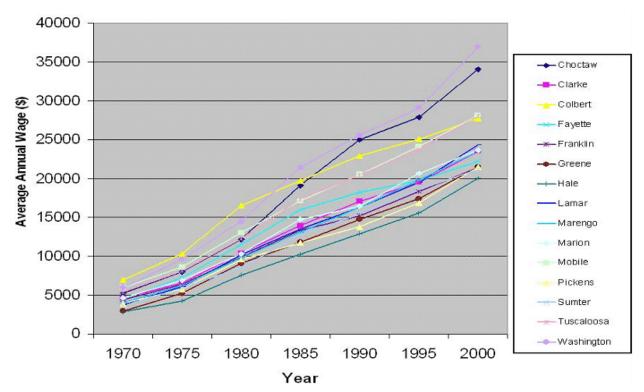


Figure 12: Average annual wage in the study area, 1970-2000.

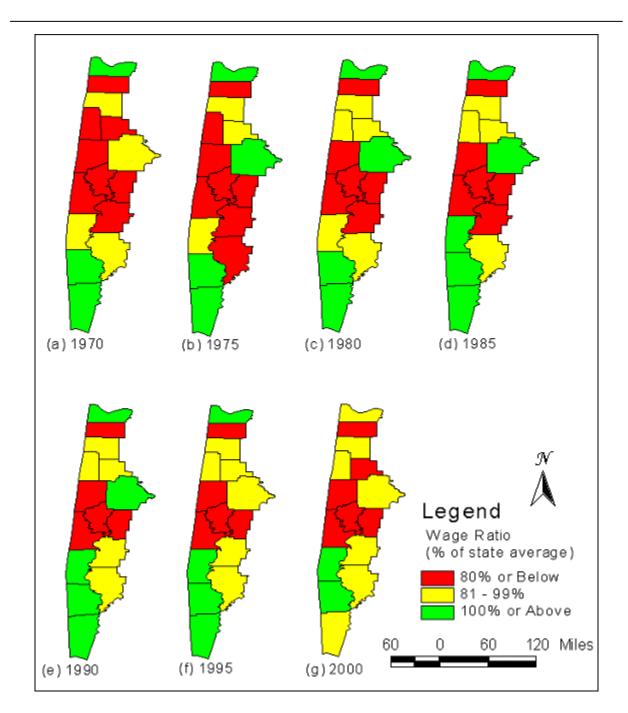


Figure 13: 5-year incremental average wages relative to state average, 1970-2000.

4.4. Per Capita Income

Per capita income in 5-year intervals is available from the US Census (Figure 14). Per capita income in the study area relative to the US average clearly demonstrates the area's depressed nature and the need for economic development. In 1970, three counties (Mobile, Tuscaloosa and Colbert (Muscle Shoals/Florence) reached 75% of the US average. By 2000, only one county (Tuscaloosa) reached that relative level. At the low end, in 1970, nine counties (Washington, Clarke, Marengo, Choctaw, Sumter, Greene, Hale, Pickens and Lamar) had per capita income of

60% or less than the national average. In 2000, all the counties except Tuscaloosa were less than 75%.

The relative per capita picture is similar when comparing to the Alabama sate average. Much of the middle of the study area shows almost the same results when compared to the national average. Mobile Tuscaloosa and Colbert (Florence/Muscle) are the consistent exception to the depressed picture of the socio-economic conditions of the corridor area. In 1970, eight counties (Washington, Choctaw, Marengo, Sumter, Greene, Hale, Pickens, Lamar and Marion) were 80% or less of the state average and only Colbert equaled the state average. In 1975, only Mobile County equaled the state average. During the period the only counties that reached the state average were Mobile, Tuscaloosa, Franklin and Colbert. By the end of the study period, only Tuscaloosa equaled the state average and nine counties (Washington, Choctaw, Sumter, Hale, Greene, Pickens, Fayette, Lamar and Marion) were 80% or less of the state average.

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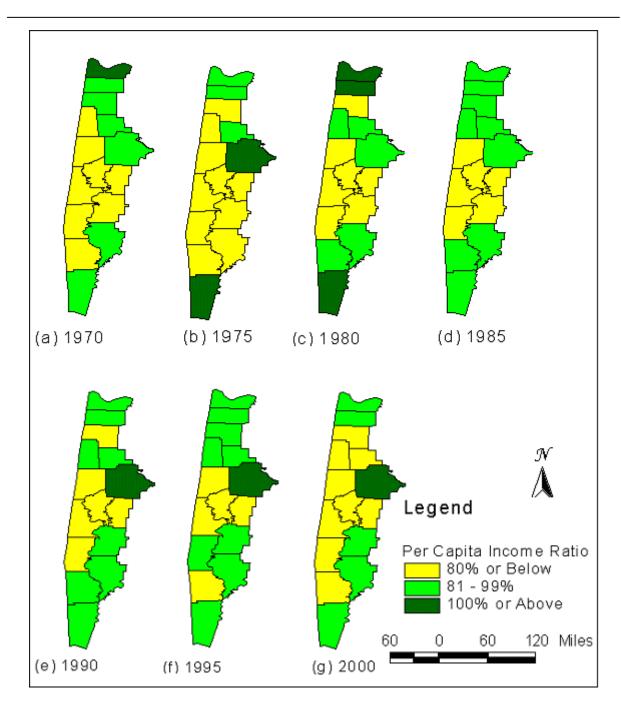


Figure 14: 5-year incremental per capita income as a percentage of state average, 1970-2000.

5. Summary

The data presented here clearly document the depressed nature of the area through which the proposed West Alabama corridor will be located. The trends are particularly dramatic for the rural areas. Each of the socio-economic indicators underlined the decline in the region and the desperate need for economic development. A transportation corridor should be able to play a part in the revitalization of the area.

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